DOCUMENT RESUME

ED 120 126 SP 009 898

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TITLE	The Role of Abstract Preferences in Determining Student Behavior in Problem Solving Tasks Within a Piagetian Framework.
PUB DATE	76
NOTE	19p.; Paper presented at the Annual Meeting of the National Science Teachers Association (24th, Philadelphia, Pennsylvania, March 19-23, 1976)
EDRS PRICE	MF-$0.83 HC-$1.67 Plus Postage
DESCRIPTORS	*Abstract Reasoning; *Cognitive Ability; Cognitive Development; Cognitive Processes; *Logical Thinking; *Problem Solving; Task Analysis; *Thought Processes
IDENTIFIERS	*Piagetian Theory

ABSTRACT

Preference scores were determined for several different groups of students ranging in age from seven to adult. In addition, instruments were administered to determine the cognitive level at which the students were capable of functioning. Comparisons between the students' cognitive level and preferences were made. The results indicated that the students' preference to a method of solving a problem was independent of the cognitive level of development. However, the data support the premise that preferences may be task dependent. Children who are only capable of functioning at the concrete level of operations frequently prefer to attempt to solve problems in a manner through which they are not capable of success. Further, formal operational children frequently prefer to solve problems in a concrete manner. A possible explanation is that they feel that the concrete mode will either be easier or more fun; additional research, however, will be needed to confirm this explanation. Another aspect of these studies compared the manner in which students actually began to solve a problem with a previously stated preference. It was found that the overall "consistent score" for both groups was similar; formal students, however, were generally more successful in solving the problems. (References and tables are included.) (Author)

THE ROLE OF ABSTRACT PREFERENCES IN DETERMINING STUDENT BEHAVIOR IN PROBLEM SOLVING TASKS WITHIN A PIAGETIAN FRAMEWORK

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Presented at the
24th annual meeting
of the

NATIONAL SCIENCE TEACHERS ASSOCIATION

Philadelphia, Pennsylvania

March 19-23, 1976

INTRODUCTION

Many people consider problem solving an important component of a science program. Teachers who allow their students to indulge in this activity frequently recognize that not all students attempt to solve the problems in the same manner. Upon closer inspection one can discern that the students may be classified according to the cognitive level at which they are functioning. For example, some students may be manipulating objects in an attempt to arrive at a solution to a particular problem while other students may be attempting to solve the problem through reading and/or abstract thoughts. Within a Piagetian context, one could say that the students who are reading may be functioning at a higher cognitive level than the students who are manipulating the objects.

If all the students in the above example were capable of formal operational thought, then in Piagetian terms one could say that some of the formal thinkers were solving problems in a concrete manner thus suggesting below capacity functioning or a regression by the student to the concrete level of mental operations. In many cases it is assumed that the student's lack of logical structures accounts for much of this "underachieving". And indeed, a student's lack of success in solving the problem in an abstract manner may be the result of inadequate logical structures within the student's brain; however, recent studies have shown that a student's preference to a particular method of solving problems may very well account for much of his or her "underachieving".

Since this paper was written to supplement a verbal presentation, much of the related background information and associated details have been omitted. For this information, readers are refered to the three references at the end of this paper.

OBJECTIVES

The purpose of this presentation is three-fold: First we would like to discuss an experimental instrument which we believe can be used to categorize student's problem solving preferences based upon the degree of formal thought required to successfully implement a given problem solving strategy. A copy of the instrument is in Appendix A, and we hope that you will take time to read it and send your written suggestions to us. Second, we will present some research evidence which describes the very important role of individual preferences in determing if a student will or will not attempt to function at the formal level of thought as defined by Piaget. Third, we will present research evidence concerning the relationship between an individual's preference and his or her ability to successfully implement his or her problem solving preferences.

DESIGN

Although several different sets of data will be mentioned in this paper, the general research design was similar for all of the students. Students were first "tested" to determine their cognitive level of mental operation. In many instances this was done by the administration of the Shipley Test of Abstract Reasoning. Scores from this test have been found to have significant correlations with scores earned by students on several traditional Piagetian Tasks. This allowed us to form groups which at least approximately correspond to concrete and formal operational levels. In one study conducted at the elementary grade level the cognitive level was determined by the use of Piagetian Tasks such as conservation of area, substance, etc.

Preference scores in most of the studies were derived from the preference survey in Appendix A. In one of the studies the preference score was derived from a series of problem solving situations for which the child was asked to state his or her preference to a method of solution.

In each study subgroups such as grade level, sex, academic major, and cognitive level were formed and the relationship between abstract ability (cognitive level of thought) and abstract preference was examined.

In one of the studies students were asked to actually solve three problems for which they had previously indicated a problem solving preference. In addition their degree of success was recorded thus allowing comparisons to be made between their degree of success and their stated cognitive level of development and preferences.

RESULTS

The tables in this section will all relate to one particular study which used high school science students as subjects; however, summaries of some data from other studies will be included in the narrative at the end of this section.

The data in Table 1 indicate that there are very significant differences in the cognitive abilities of the formal and concrete groups of students; however, there are no significant differences in the abstract preference scores of these two groups of students. Nor is there a significant correlation between the abstract ability scores and the abstract preference scores of the formal and concrete students (Table 2). This lack of correlation between ability and preference also holds true for the subgroups of males and females (Table 2).

Table 3 examines the "consistent scores" for formal and concrete groups of students. Consistent Scores indicate the degree to which a student actually attempted to solve a problem in comparison with a previously stated preference for solving that particular problem. The Chi-Square Value of 1.37 allows us to state that with respect to the "consistent score" for these three tasks the formal and concrete students do not significantly differ.

A Chi-Square analysis was used to examine the actual problem solving preferences for formal and concrete students in three separate tasks (Table 4). The only significant Chi-Square Value is for task number three, suggesting that a student's actual preference may be task dependent.

Table 5 shows the percentages of concrete and formal operational students which attempt and successfully complete the task as they indicated on the perference survey. One may see that although several concrete students prefer to solve the problems in an abstract manner, they are unsuccessful in their efforts. However, when examining the

TABLE 1 - A Comparison Between Formal and Concrete Operational Children With Respect to Abstract Preference Scores and Abstract Ability Scores.

Group	n	$\overline{X}$	s	t
	Abstract Preferences (Males)			
Formal Operational	15	8.60	2.23	0.23
Concrete Operational	6	8.83	1.60	
	Abstract Preferences (Females)			
Formal Operational	36	8.58	1.71	1.35
Concrete Operational	17	7.88	1.87	
	Abstract Preferences (Combined)			
Formal Operational	51	8.59	1.86	0.99
Concrete Operational	23	8.13	1.82	
	Abstract Ability (Males)			
Formal Operational	15	18.73	0.88	7.36*
Concrete Operational	6	15.00	1.41	
	Abstract Ability (Females)			
Formal Operational	36	18.72	0.78	11.00*
Concrete Operational	17	15.47	1.37	
	Abstract Ability (Combined)			
Formal Operational	51	18.73	0.80	13.32*
Concrete Operational	23	15.35	1.37	

*$p < .001$

TABLE 2 - Product Moment Correlation Coefficients Between Abstract Ability and Abstract Preference Scores for Five Different Sub-Groups of High School Students.

Sub-Group	n	r	Level of Significance
Males	23	-.02	n.s.
Females	59	.13	n.s.
Formal	51	.08	n.s.
Concrete	23	.09	n.s.
Total Group	80	.09	n.s.

TABLE 3 - Chi-Square Analysis of the Consistent Scores for Two Groups of Students in Three Tasks.[a]

Group	Task 1	Task 2	Task 3	Total
Formal	27 (25.63)[b]	30 (28.48)	32 (34.89)	89
Concrete	9 (10.37)	10 (11.52)	17 (14.11)	36
Total	36	40	49	125

[a]For 2 d.f. chi-square (.01) = 9.21, chi-square (.05) = 5.99. Chi-square value = 1.37.

[b]Expected frequencies are in parentheses.

TABLE 4 - Chi-Square Analysis of the Actual Problem Solving Preferences for Two Groups of Students for Three Tasks.[a]

Group	Actual Preference: More Abstract	Actual Preference: Less Abstract	Total
	Task 1		
Formal	8 (8.22)[b]	42 (41.78)	50
Concrete	4 (3.78)	19 (19.22)	23
Total	12	61	73
	Task 2		
Formal	21 (19.18)	29 (30.82)	50
Concrete	7 (8.82)	16 (14.18)	23
Total	28	45	73
	Task 3		
Formal	17 (13.7)	33 (36.3)	50
Concrete	3 (6.3)	20 (16.7)	23
Total	20	53	73

[a]For 1 d.f. chi-square (.01) = 6.64, chi-square (.05) = 3.84. Chi-square values; task 1 = 0.02, task 2 = 0.89, task 3 = 4.00.

[b]Expected frequencies are in parentheses.

TABLE 5 - Percentages of students attempting and successfully solving three tasks in the manner that they previously stated to be their preference.

Group	% Attempting Abstract Solution	% Successful	% Attempting Concrete Solution	% Successful
		TASK ONE		
Concrete	50.0	00.0	36.8	21.1
Formal	62.5	37.5	52.4	26.2
		TASK TWO		
Concrete	28.6	00.0	50.0	6.3
Formal	76.2	23.8	65.5	37.9
		TASK THREE		
Concrete	0.0	0.0	85.0	65.0
Formal	5.9	0.0	96.9	87.5

success for those who prefered to use the concrete approach, one may see that the concrete students were almost as successful as the formal students.

Data from other studies have indicated similar trends. Although there is a very significant difference among the cognitive ability scores for students in five different grade levels, there is no significant difference in their abstract preference scores. Further, product moment correlations indicate no significant correlations between the abstract ability scores and the abstract preference scores of the following groups of students: 63 eighth grade students, 37 ninth grade students, 27 college seniors, 29 eighth grade males, 34 eighth grade females, 38 low abstract ability eighth graders, 22 transitional eighth grade students, 68 college freshmen females, 28 transitional college freshmen, 200 college freshmen science students, 266 college freshmen non-science students, 121 college biology majors, and 54 college natural science majors. Similar results have been found for first and second grade students. That is, no correlations have been found between abstract preferences and cognitive ability levels.

SUMMARY

Preference scores were determined for several different groups of students ranging in age from 7 to adult. In addition instruments were administered to determine the cognitive level at which the students were capable of functioning. Comparisons between the student's cognitive level and preferences were made. The results indicated that the student's preference to a method of solving a problem was independent of his or her cognitive level of development. However, the data to support the premise that preferences may be task dependent.

Children which are only capable of functioning at the concrete level of operations frequently prefere to attempt to solve problems in a manner for which they are not capable of success. Further, formal operational children frequently prefer to solve problems in a concrete manner. A possible explanation is that they feel that the concrete mode will either be easier or more fun; however, additional research will be needed to confirm this explanation.

Another aspect of these studies compared the manner in which students actually began to solve a problem with a previously stated preference. It was found that the overall "consistent score" for both groups was similar; however, formal students were generally more successful in solving the problems.

For a more complete discussion of these and other findings, the reader is directed to the references.

REFERENCES

REFERENCES

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APPENDIX A

Abstract Preference Survey

This is NOT a test, but rather a preference survey. There are no right or wrong answers--only preferences. It consists of 18 problems each of which may be solved by more than one method. (Assume all methods could, if properly used, result in a correct solution.) As you read the items, select the method which YOU would prefer to use in arriving at the solution. You do not need to actually solve the problem at this time--just indicate which method you would prefer to use if someone asked you to solve the problem.

1. You are given three pieces of metal and are asked to identify them as to composition. Which would you more likely do first?

   A. Consult references such as handbooks, textbooks, and read about the theory and about the theory and properties of metals.
   B. Test the metals with acids, bases, and other liquids in the laboratory to determine their properties.

2. You have just found an interesting fossil but don't know what it is. Which of the following methods would you use to identify the fossil?

   A. Study the fossil through written descriptions.
   B. Compare it to pictures which you have of various named fossils.

3. If you wanted to understand how a certain piece of equipment operated, would you

   A. Read the instructions as you examined and used the equipment.
   B. Read the instructions thoroughly prior to examining or using the equipment.

4. When driving in an area which is new to you, which of the following do you prefer to do?

   A. Decide upon the proper direction by "instinct" and/or reason.
   B. Decide upon the proper direction by using a map.

5. Read the following sentence: "I am very glad I do not like onions, for if I liked them, I would always be eating them, and I hate eating unpleasant things." Which of the following comments would you prefer to make concerning that sentence?

   A. Onions are unpleasant for some people to eat.
   B. There is a contradiction between "if I liked them" and "onions are unpleasant".

6. You want to learn how the parts of an electric motor fit together. In addition, you want to learn this as quickly as possible. Which of the following would you choose?

   A. Look at diagrams and read how the parts fit together.
   B. Take an actual electric motor apart and see how the parts fit.

7. On your last birthday you were given a small wooden puzzle. It has about 12 pieces and when properly assembled, it forms a solid cube. You are anxious to assemble this as easily as possible. Would you best like to

   A. Follow a diagram of how to put the pieces together.
   B. Follow the verbal instructions of a friend.

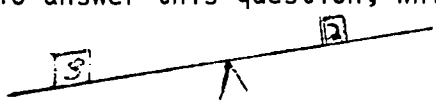
8. You are given a drycell battery, two light bulbs, some wires, and a switch. You are asked to hook up the materials in such a way as to make both lights burn at the same time. What would you more likely do first?

   A. Study about electric circuits, sketches, diagrams, and then draw some yourself.
   B. Take the given materials and actually manipulate them in order to get the system to work.

9. You have been given the task of determining a person's blood type. Which of the following best describes the method you would prefer to use in this determination?

   A. Using a sample of blood provided, you would test it in a laboratory to determine its type.
   B. Using an accurate family tree showing blood types of many blood relatives, (but not the type of the individual in question) you would determine the blood type of the individual by applying various principles of heredity and genetics which would be provided for you.

10. A 2 gram weight is placed exactly 6 centimeters to the right of a fulcrum. Another weight (3 grams) is placed 7 Cm to the left of the fulcrum. Where would the 3 gram weight need to be placed to have the system balanced? To answer this question, which of the following methods would you choose?



   A. A mathematical approach using formulas.
   B. Actual manipulation of the weights.

11. You have decided to play the role of a cook and wish to try making something you have never made before. Which of the following would you prefer to use as a source of instruction?

   A. Learn how to do it by watching a famous cook on T.V.
   B. Learn by reading one of the famous T.V. cook's book.

12. Given the same situation as above:

   A. Learn by having a neighbor explain it to you.
   B. Learn by watching a famous cook on T.V.

13. You have been given 2 chemicals in liquid form and asked what happens if they are mixed together. How would you prefer to find out?

   A. Using chemical principles, a probable solution could be deduced.
   B. Under controlled conditions the two chemicals would be mixed together and observations would be made.

14. You just bought a new game which is designed to illustrate the basic principles of genetics. How would you prefer to learn to play this game?

   A. Begin immediately and read the rules as you play.
   B. Read the rules until you understand how to play and then play.

15. You are about to build a picnic table for your own use in your backyard. Which of the following methods would you prefer to use in the building of the tables?

    A. Follow a set of plans (either your own or a set you purchased).
    B. Build the table "from your head" as you proceed.

16. You see a glass three-quarters full of water. When a stone is placed into the water, you notice the water level goes up. Which of the following would you prefer as a reason for your observation?

    A. The water will rise because the stone takes up space at the bottom.
    B. The stone is heavy; it will make the water rise.

17. If you were to visit a friend in another city for the first time, which of the following would you prefer to help you visualize the location of your fiends's home?

    A. A little map sketched out for you on a piece of paper.
    B. A verbal set of instructions given to you.

18. You have been given a square object of unknown composition. Its weight and size are known. You wonder if it will float if placed in various liquids such as alcohol, oil, water, and gasoline. How would you prefer to determine if this object would float in each liquid?

    A. By experimentation under controlled conditions, you would observe the results.
    B. Calculate the objects density and compare this to the density of the various liquids. Formulas which you needed would be provided.